Basin-Scale Leakage Risks from Geologic Carbon Sequestration: Impact on CCS Energy Market Competitiveness

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Widespread adoption of carbon capture and geologic sequestration (CCS) will occur only if CCS is economically competitive, politically feasible and if it comes close to meeting the USDOE performance goals of 99% CO_2 storage permanence and a 10% electricity cost premium. The greatest uncertainty lies with the costs and liabilities from imperfect performance of a CCS project, in which some of the CO_2 stored in deep geologic formations leaks out. This leakage translates into the loss of carbon mitigation credit, as well as potential damages to and interferences with other subsurface resources such as hydrocarbons or potable water. We have assembled a multidisciplinary team of experts for this project in which we seek to link energy market competitiveness of CCS with economic losses from CO_2 leakage. We will develop a framework to quantify leakage risk in probabilistic terms, and combine it with a basin-scale model of competing subsurface land uses. Model output will be used to evaluate market competitiveness of alternative geologic storage options and to assess implications of different regulatory and legal frameworks. The objectives are:

1. Develop a framework to examine CCS investment decisions in light of uncertainty in CO_2 leakage risks, potential subsurface liability and the associated losses in carbon credits.
2. Quantify and bound CCS project risks that derive from damages and interferences with competing subsurface resources, and examine regulatory and liability-management alternatives.
3. Determine the role of geochemical reactions in affecting the probability of CO_2 leakage through alteration of the integrity of caprocks and well cements.

Approach, Tasks and Activities: The geographic focus of this project will be the states that are part of the DOE's Midwest Regional Carbon Sequestration Partnership (MRCSP). The test injection into the Bass Island Dolomite Formation in the Michigan Basin will serve as the specific application site, but a basin-scale approach will be taken to examine impacts on competing subsurface uses. We will expand the capabilities of Princeton's existing ELSA model, which uses a probabilistic approach to predict leakage rates through preferential flow paths. Permeability changes in caprock and well-cements will be represented using simplified mathematical rules determined from detailed geochemical reaction simulations. We will also examine the impacts of co-injection of SO_2. Multiple subsurface land uses will be incorporated into a GIS-based basin-scale model. Data on the cost of past damages for related interferences will be used to estimate a range of costs of subsurface damages. Energy marketplace competitiveness will be examined by building on the existing energy systems analysis model, US MARKAL and focusing on target states.

The expected impact of this work is threefold. First, we will reduce uncertainties in predictions of CO_2 leakage rates by quantifying the extent to which geochemical reactions can jeopardize the integrity of caprocks and well cements. Second, we will demonstrate how CO_2 leakage and subsurface liability impact energy market competitiveness of CCS in the Midwest. Third, we will produce a general framework for analysis of CCS energy marketplace competitiveness nationwide.